

# Edaphics and Fire: An Interpretative Ecology of Lowland Forest Vegetation on Granite in Northeast Tasmania

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Forest, scrub and moorland vegetation near Old Chum Dam in northeast Tasmania is described. Analyses of the floristics and some environmental variables suggest that moisture availability, drainage and edaphic factors have a major influence on vegetation composition and structure. The vegetation itself, largely through differences in the flammability of its understorey, encourages fire frequencies and intensities which maintain its current heterogeneity. Trends observed in the study area are similar to those reported from comparable forested areas in Tasmania and on the southeastern Australian mainland.

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## INTRODUCTION

The vegetation of a forested area near Old Chum Dam, in northeastern Tasmania, was surveyed in March 1990 as part of a wider study into the effects on the biota of forestry operations and forest conservation prescriptions. The vegetation is representative of that occupying much of the forested lowland country in the Northeast.

There are few published descriptions of lowland vegetation in northeastern Tasmania, though the upland vegetation has been documented more thoroughly (e.g. Ellis, 1985; Davies and Davies, 1989). Remnant heaths, forests and woodlands occurring on the Great Northern Plain, to the north of the study area, are described (Kirkpatrick and Wells, 1987), and forest vegetation on Spurrs Rivulet, to the east of the study area, has been analysed (Peters, 1984). Stephens and Cane (1938) and Pinkard (1980) provide general descriptions of the vegetation of northeastern Tasmania, and its relationship with the environment. Statewide analyses of major vegetation types (e.g. Kirkpatrick, 1977; Jarman *et al.*, 1984; Duncan and Brown, 1985; Kirkpatrick *et al.*, 1988; Jarman *et al.*, 1988; Pannell, 1992) include forest and non-forest communities found in the Northeast.

Species nomenclature in this paper follows Buchanan *et al.* (1989).

## THE STUDY AREA

The study area consists of undulating country in the upstream catchment of the Great Musselroe River, in the vicinity of Old Chum Dam (41°06'S 148°03'E). The general location is shown in Figure 3. Altitude varies from 100m to 250m above sea level. The area occurs within the humid warm climatic zone defined by Gentilli (1972). Average annual rainfall at Pioneer, some 9km to the west of Old Chum Dam, is 978mm and has a pronounced seasonality. January is the driest month (mean monthly rainfall of 45mm) and July the wettest (mean monthly rainfall of 112mm). Temperature records are available

from St Helens, a coastal town 33km to the southeast. February is the hottest month (mean monthly maximum 22.9°C, minimum 11.9°C) and July the coldest (mean monthly maximum 14.2°C, minimum 2.5°C). Temperatures in the study area are likely to be more extreme than those on the coast.

The ground rock is Devonian/Carboniferous granite, which crops out at several locations in the study area. The soils are gradational and comprise gravels and coarse-grained sands on ridges and upper slopes, with particle size becoming finer downslope, in drainage basins and along creeklines. Poorly drained flats, supporting moorland and scrub, also have relatively fine soils which are high in organic content.

At a broad level, the vegetation in the general area varies in response to landform, and consequently moisture availability, drainage and fire history. Forests with rainforest understoreys are dominated by *Acacia melanoxylon* (and occasionally *Eucalyptus obliqua*), and are confined to humid creeklines and gullies. *E. obliqua* wet sclerophyll forests are common on shaded slopes. Dry sclerophyll forests dominated by *E. obliqua* or *E. amygdalina* are the most widespread vegetation types in the area. *E. ovata* woodlands occur on poorly drained sites, grading into shrublands and *Gymnoschoenus sphaerocephalus* (button-grass) moorlands as drainage becomes progressively more impeded.

The study area is entirely contained in State forest, and some of its taller forests have been logged selectively in the past. Some disturbances, including construction of Old Chum Dam and systems of water races, are associated with tin mining prior to 1950. Vegetation in the general area is now being managed for a range of uses, including harvesting of sawlogs and pulpwood. The study area includes a logging coupe (Gladstone 07), which was logged (using partial logging techniques) in late 1990. Ongoing studies in the coupe, and a comparable control area to the east of Old Chum Creek, will allow monitoring of the impact of forest practices, including establishment of wildlife habitat strips. Some analyses of the fauna of the coupe and control area have been published (Taylor and Turner; 1992; Taylor *et al.*, 1993; Cale, 1994; Walsh *et al.*, 1994).

## METHODS

Information on the vegetation and physical environment was collected from 66 sites of different dimensions. Fifty-three of the sites coincided with plots established in an area of about 350ha, in the course of the wildlife studies in the coupe and the control area. These plots were chosen to sample the range of forest types in the coupe, and comprised twenty-eight 50m x 50m plots, and ten plots of 10m radius centred on light traps used for insect collection. Two plant associations could be delineated in seventeen 50m x 50m plots, and the vegetation of both associations was sampled separately in these plots. An additional thirteen sites were sampled to include predominantly non-forest vegetation in the analysis, thereby providing a more complete picture of the vegetation of the general area. Eleven of the latter sites were located within the wildlife study area, and two were located some 5km to the north. The additional sites had a nominal 30m radius, except along creeklines, and were confined to relatively homogeneous vegetation.

Floristic information obtained for all sites comprised lists of vascular plant species, and a Braun-Blanquet rating of their cover and abundance (Mueller-Dombois and Ellenberg, 1974). Height and cover of vegetation strata were recorded and qualitative cover ratings were given for bryophytes, ground litter, surface rock, bare ground, and logs on the ground. The number of stags (dead trees) standing on each site was also noted. Physical site information recorded included landform, aspect, slope, drainage and obvious past land use and fire history. The fire history of the area was interpreted indirectly, mainly from attributes of forest structure, distribution of eucalypt regeneration, characteristics of epicormic shoots on eucalypts, extent of charcoal and fire damage to trees (including 'roll arounds' on fire-scarred trees), and node counts on *Banksia*

*marginata* individuals (Brown and Podger, 1982; Podger *et al.*, 1988). Sub-surface soil samples (5-15cm depth) were collected from most sites, for further evaluation of the relationship between vegetation and soil physical and chemical attributes.

The floristic data were transferred to DECODA files (Minchin, 1991). The polythetic divisive program TWINSpan (Hill, 1979) was used to classify sites on the basis of species cover/abundance data. Another classification based on species presence/absence data gave similar results, but was marginally less informative. The sorted matrix of species and sites allows the composition of the vegetation group defined at each level of division to be perceived. The data were ordinated using hybrid multi-dimensional scaling (Minchin, 1987). This technique often gives a more realistic display of the trend in vegetation compositional change, and the relative disposition of sites, than other ordination techniques (Minchin, 1987).

Soil samples from 31 sites were analysed for moisture loss, pH, organic content and texture (sand, silt and clay), using techniques described in Herbert *et al.* (1994). The samples were chosen to include sites from the range of classificatory groups, with consideration also being given to the position of the sites on the ordination. These data were fitted to the ordination diagrams by vector fitting, using DECODA to explore the relationships between the trends in floristic variation and the edaphic factors.

## RESULTS AND DISCUSSION

A total of 171 vascular species were recorded from the sites surveyed; they comprised 28 pteridophytes, 48 monocotyledonous angiosperms and 94 dicotyledonous angiosperms. Only three species are Tasmanian endemics, the paucity of endemics according with trends described by Kirkpatrick and Brown (1984). No species of national or regional conservation significance were observed. Three exotic species were recorded. A full list of vascular species is available from the authors.

The TWINSpan analysis, using modified cover/abundance data, resulted in twelve interpretable plant groups (communities) being identified. The classification revealed a trend in floristic composition from tall *Acacia melanoxylon* and *Eucalyptus obliqua* forests with mesomorphic understoreys, to scrub and moorlands with diverse low shrub and ground strata of scleromorphic species. The TWINSpan table showed that some species (e.g. *Gleichenia microphylla*, *Xanthorrhoea australis*, *Atherosperma moschatum*) have a high fidelity to particular classificatory groups, while others (e.g. *Pteridium esculentum*, *E. obliqua*, *E. amygdalina*, *Gonocarpus teucroides*) occur in most of the groups delineated. Table 1 summarises the composition, structure, habitat and extent of each community. More detailed information on the communities is given in Appendix 1.

Plotting of site scores on the primary and secondary axes of the ordination (Figure 1) suggested that several factors, some interrelated, were responsible for the distribution of native vegetation in the area.

A distinct trend related to moisture availability, insolation and soil fertility is evident in the orientation of the environmental variables, when these are superimposed on the ordination (Figure 2). Most of the measured variables are aligned in much the same direction, indicating a degree of autocorrelation. There is also a trend, running more or less orthogonally to the major alignment, which is related to site drainage.

*Acacia melanoxylon* gully forest (Group A) occupies the most 'favourable' sites, such as well defined gullies and creekline corridors. These are relatively shaded, humid, protected from fire, and have moderately high soil moisture contents, and higher proportions of silt and clay, than sites supporting other forest groups. The gully forests grade into tall *E. obliqua* wet sclerophyll woodland and forest (Groups B and C) on sites which are less humid but are shaded and burnt infrequently (typically at intervals greater than 30 years). At the other extreme, heathy *E. amygdalina* dry sclerophyll forest (Group F), sedgey



TABLE 1  
Floristic groups and their attributes in the study area.

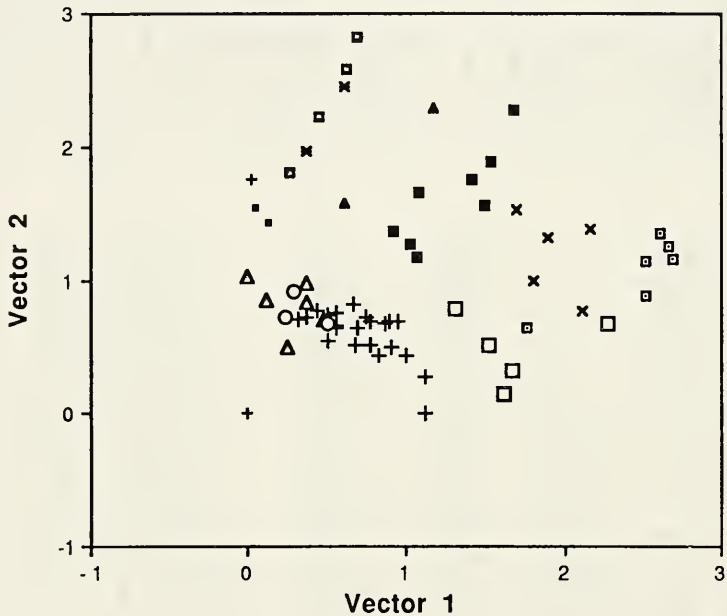
Group	Characteristic species and structure	Typical habitat (Fire frequency)	Extent
A: <i>Acacia melanoxylon</i> gully forest	Trees: <i>A. melanoxylon</i> , ( <i>E. obliqua</i> , <i>Atherosperma moschatum</i> ) Understorey: Dense medium to tall mesomorphic shrubs ( <i>Pomaderris apetala</i> , <i>Olearia angophylla</i> ) and <i>Dicksonia antarctica</i> over ground ferns ( <i>Blechnum</i> spp., <i>Polystichum proliferum</i> ) and graminoids ( <i>Lepidosperma elatius</i> ). Epiphytic ferns and bryophytes common.	Corridors along creeklines and gullies, and stream flats (>100 years)	Local
B: <i>Eucalyptus obliqua</i> tall wet sclerophyll woodland	Trees: <i>E. obliqua</i> , ( <i>E. viminalis</i> ) Understorey: Dense medium to tall mesomorphic shrubs (as above) with trunked ferns ( <i>Dicksonia antarctica</i> , <i>Todea barbara</i> , <i>Gyneria australis</i> ) over ground ferns ( <i>Blechnum</i> spp., <i>Calceita dubia</i> , <i>Pteridium esculentum</i> ) and graminoids ( <i>Lepidosperma elatius</i> , <i>Gahnia grandis</i> )	Shaded lower slopes and along creeklines (50 – 100 years)	Local
C: <i>Eucalyptus obliqua</i> tall wet sclerophyll forest	Trees: <i>E. obliqua</i> , ( <i>E. viminalis</i> ) Understorey: Dense medium mesomorphic shrubs (e.g. <i>Pomaderris apetala</i> , <i>Zieria arborescens</i> ) and scleromorphic shrubs (e.g. <i>Acacia verticillata</i> , <i>Pullenaea juniperina</i> ) over ferns ( <i>Pteridium esculentum</i> , <i>Calceita dubia</i> ) and graminoids ( <i>Lepidosperma elatius</i> )	Shaded middle and lower slopes (30 – 50 years)	Common
D: <i>Eucalyptus obliqua</i> – <i>Eucalyptus amygdalina</i> damp sclerophyll forest	Trees: <i>E. obliqua</i> , <i>E. amygdalina</i> Understorey: Moderately dense medium to lower shrubs ( <i>Olearia lirata</i> , <i>Acacia verticillata</i> , <i>Acacia terminalis</i> , <i>Pullenaea juniperina</i> , <i>Leptospermum scoparium</i> ) over ferns ( <i>Pteridium esculentum</i> ) and graminoids ( <i>Lepidosperma</i> spp., <i>Gahnia grandis</i> )	Partly shaded middle and lower slopes, shaded upper slopes (20 – 30 years)	Widespread
E1: Scrubby <i>Eucalyptus obliqua</i> – <i>Eucalyptus amygdalina</i> dry sclerophyll woodland	Trees: <i>E. obliqua</i> , <i>E. amygdalina</i> Understorey: Dense medium shrubs ( <i>Melaleuca squarrosa</i> , <i>Leptospermum</i> spp., <i>Acacia verticillata</i> ) over graminoids ( <i>Gahnia grandis</i> ) and sporadic ferns ( <i>Blechnum</i> spp., <i>Pteridium esculentum</i> , <i>Gleichenia microphylla</i> )	Basins and soakages with impeded drainage (15 – 30 years)	Common
E2: Scrubby <i>Eucalyptus amygdalina</i> dry sclerophyll woodland	Trees: <i>E. amygdalina</i> Understorey: Similar to group E1	Sites which are less fertile or have more impeded drainage than E1 sites (15 – 30 years)	Local

TABLE 1 cont'd  
Floristic groups and their attributes in the study area.

Group	Characteristic species and structure	Typical habitat (Fire frequency)	Extent
F: Heathy <i>Eucalyptus amygdalina</i> – <i>Eucalyptus obliqua</i> dry sclerophyll forest	Trees: <i>E. amygdalina</i> , <i>E. obliqua</i> Understorey: Sparse to moderately dense scleromorphic shrubs ( <i>Leptospermum scoparium</i> , <i>Epacris impressa</i> , <i>Lomatia tinctoria</i> , <i>Acacia terminalis</i> ) over dense ferns ( <i>Pteridium esculentum</i> ) and herbs	Insolated middle and upper slopes and ridgelines (10 – 20 years)	Widespread
G: <i>Allocasuarina littoralis</i> forest	Trees: <i>Allocasuarina littoralis</i> , ( <i>E. amygdalina</i> , <i>E. viminalis</i> ) Understorey: Sparse scleromorphic shrubs ( <i>Leptospermum scoparium</i> , <i>Banksia marginata</i> ) over sparse ferns ( <i>Pteridium esculentum</i> ) and herbs	Broad ridges (>30 years)	V. local
H: Heathy <i>Eucalyptus amygdalina</i> dry sclerophyll woodland	Trees: <i>E. amygdalina</i> Understorey: Diverse and moderately dense low to medium scleromorphic shrubs ( <i>Allocasuarina</i> spp., <i>Banksia marginata</i> , <i>Xanthorrhoea australis</i> , <i>Aotus ericoides</i> , <i>Kunzea ambigua</i> , <i>Acacia</i> spp.) over moderately dense graminoids ( <i>Gahnia</i> spp., <i>Leptosperma concavum</i> , <i>Patersonia fragilis</i> ) and ferns ( <i>Pteridium esculentum</i> )	Sandy flats (10 – 20 years)	Local
I: Sedgey <i>Eucalyptus amygdalina</i> woodland/scrub	Trees: <i>E. amygdalina</i> , ( <i>E. ovata</i> ) Understorey: Dense low to medium scleromorphic shrubs ( <i>Melaleuca</i> spp., <i>Leptospermum</i> spp., <i>Boronia</i> spp., <i>Epacris lanuginosa</i> ) over dense graminoids ( <i>Gymnoschoenus sphaerocephalus</i> , <i>Gahnia grandis</i> , <i>Leptocarpus tenax</i> , <i>Empodisma minus</i> )	Margins of poorly drained flats and soakages (8 – 15 years)	V. Local
J: Sedgey <i>Eucalyptus ovata</i> low woodland/scrub	Trees: <i>E. ovata</i> Understorey: Similar to group I	Poorly drained flats and soakages (8 – 15 years)	Local
K: <i>Gymnoschoenus sphaerocephalus</i> moorland	Trees: ( <i>E. ovata</i> ) Understorey: Moderate dense low scleromorphic shrubs ( <i>Melaleuca</i> spp., <i>Leptospermum</i> spp., <i>Sprengelia incarnata</i> , <i>Epacris lanuginosa</i> ) over dense graminoids ( <i>Gymnoschoenus sphaerocephalus</i> , <i>Leptocarpus tenax</i> , <i>Empodisma minus</i> , <i>Patersonia fragilis</i> )	Poorly drained flats and soakages (5 – 12 years)	Local

woodland/scrub (Groups I and J) and moorland (Group K) occupy 'unfavourable' sites, which receive relatively high amounts of solar radiation, have higher fire frequencies (typically at intervals less than 20 years), and have sandy soils with low moisture contents (Group F) or have impeded drainage (Groups I, J and K). The influence of drainage on floristic composition can be seen by the position on the ordination (Figure 1) of scrubby woodlands (Groups E1 and E2), which have a dense understorey dominated by *Melaleuca* spp. and *Leptospermum* spp., and occupy poorly drained soaks and basins associated with minor drainage lines. The soil samples from sites with impeded drainage had higher moisture contents and organic carbon contents than those collected from well drained sites.

Fig. 1. Ordination of the vegetation in the Old Chum Dam area.



- ▣ A *Acacia melanoxylon* gully forest
- × B *Eucalyptus obliqua* tall wet sclerophyll woodland
- C *E. obliqua* tall wet sclerophyll forest
- + D *E. obliqua* - *E. amygdalina* damp sclerophyll forest
- E1 Scrubby *E. obliqua* - *E. amygdalina* dry sclerophyll woodland
- ▲ E2 Scrubby *E. amygdalina* dry sclerophyll woodland
- △ F Heathy *E. amygdalina* - *E. obliqua* dry sclerophyll forest
- G *Allocasuarina littoralis* closed forest
- H Heathy *E. amygdalina* dry sclerophyll woodland
- + I Sedgely *E. amygdalina* woodland/scrub
- ▣ J Sedgely *E. ovata* low woodland/scrub
- × K *Gymnoschoenus sphaerocephalus* moorland

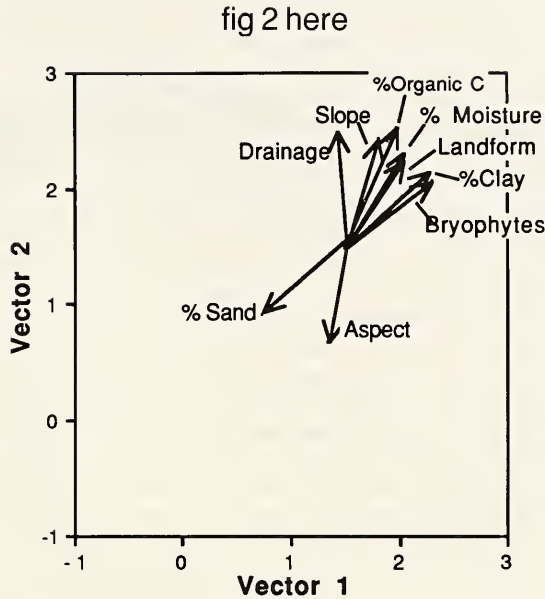


Fig. 2. Fit of vectors of some environmental variables associated with the ordinated sites.

The role of fire in influencing the structure and composition of Tasmanian lowland forests, scrub and moorland is well documented (e.g. Jackson, 1968; Brown and Podger, 1982; Podger *et al.*, 1988). It is described, for areas in northern Tasmania which are comparable to the study area, by Brown and Buckney (1983) and Marsden-Smedley and Williams (1993). Their findings accord with local information and field observations on the fire history of the Old Chum Dam area. Characteristic fire-free intervals for each community are indicated in Table 1.

The occurrence of *Atherosperma moschatum* as a secondary tree in *Acacia melanoxylon* gully forest, and the abundance and diversity of epiphytic species, indicates a period of over 100 years between fires for this vegetation type (Neyland, 1991). *A. melanoxylon* itself germinates prolifically after wildfire or other major disturbance, but is also capable of gap-phase replacement following small-scale endogenous disturbances (Pannell, 1992). However, a long period (over 200 years) without fire is likely to result in *A. moschatum* dominating such sites, and *A. melanoxylon* being represented by sporadic trees and abundant soil-stored seed. A fire-free interval of at least 30 years is surmised for *E. obliqua* tall wet sclerophyll forests and woodlands, with the intervals on more humid sites, characterised by the presence of trunked ferns, epiphytic ferns and young *A. moschatum*, probably approaching that of *A. melanoxylon* gully forest.

Fires are more frequent in heathy dry sclerophyll forests and woodlands on better drained sites, but are generally less intense than those resulting in conflagrations in wet forest types. The relatively low densities and diversities of understorey shrubs on some dry sclerophyll sites are likely to have resulted from high fire frequencies, which prevent species from reaching reproductive age, exhaust their ability to regenerate from coppice or fail to stimulate germination of soil-stored seed (Purdie, 1977b; Gill, 1981). Such fire regimes favour vegetative increasers (Purdie, 1977a), such as *Pteridium esculentum* which



regimes favour vegetative increasers (Purdie, 1977a), such as *Pteridium esculentum* which forms a dense lower stratum on many sites in the study area. Scrubby woodlands, occupying drainage basins and soaks, appear to have escaped burning for at least 20 years, despite supporting dense understoreys of flammable myrtaceous shrubs. It is possible that moist soil and litter conditions may have inhibited the spread, into scrubby woodlands, of cool fires burning in adjacent heathy forests.

Copses of *Allocasuarina littoralis* closed forest (Group G) occur locally on broad ridges which have escaped fire for at least 30 years. These stands are mainly surrounded by heathy forests with open understoreys, which tend to carry ground fires of low intensities rather than crown fires. The cool fires are unable to penetrate far into the *A. littoralis* forests, because of the relatively non-flammable foliage and litter of the dominants (Dickinson and Kirkpatrick, 1985), and the sparse nature of the understorey under the dense canopy. A similar situation has been described for *Allocasuarina verticillata* closed forest, which is associated with drought-susceptible, fire-shadow sites on dolerite in dry areas of the State (Harris and Kirkpatrick, 1991; Fensham, 1992).

Flammable myrtaceous species, epacrids and graminoids dominate low woodlands, scrub and moorlands on sites with impeded drainage. In warmer areas of the State, such as the Northeast, rates of fuel accumulation of up to 3 tonnes/ha/year in *Gymnoschoenus sphaerocephalus* moorlands (Marsden-Smedley and Williams, 1993; Marsden-Smedley, 1994) encourage a fire regime which, coupled with seasonal waterlogging on these sites, maintains the dominance of *G. sphaerocephalus* and other graminoids, and reduces the abundance and regenerative potential of shrub species (Kirkpatrick and Wells, 1987). Fires are less frequent in low woodlands and scrub, and the abundance of shrub species, and the longer interval between fires, ensures their replacement from rootstock or seed following fire in this vegetation type. In nutrient-poor areas of western Tasmania, the relative densities of woody species and graminoids are correlated with fire history, with fires in rapid succession resulting in 'ecological drift' from woodland or scrub towards moorland, extending this vegetation type far beyond its edaphic limits (Jackson, 1968; Brown and Podger, 1982). This situation is atypical in the Northeast, with moorlands being very local and strongly associated with poorly drained sites on relatively infertile soils derived from granite.

The relationship between landform and distribution of plant communities near Old Chum Dam is shown in Figure 3a. The general responses of the vegetation to moisture availability, drainage and fire are indicated in Figure 3b.

The gross trends observed in the Old Chum Dam area are consistent with those found or postulated for several other forested areas occurring at lower altitudes in northern and eastern Tasmania (e.g. Hogg and Kirkpatrick, 1974; Brown and Bayly-Stark, 1977; Kirkpatrick and Nunez, 1980; Harris and Kirkpatrick, 1982; Brown and Buckney, 1983; Duncan, 1983; Kirkpatrick and Wells, 1987). Similar trends have been reported for comparable environments on the southeastern Australian mainland (e.g. Forbes *et al.*, 1982; Keith and Sanders, 1990).

Most of the hinterland forests of northeastern Tasmania have a long history of disturbance, and contain few plant species which are either endemic or have a priority for conservation. Consequently, they have not received the research or media focus afforded more charismatic forest environments in Tasmania. The detailed patterns of variation in the vegetation, and their implications for conservation of biodiversity, remain poorly known. Further research is warranted, as obligate habitats for localised and/or relictual biota (Mesibov, 1990; Taylor and Turner, 1992) may be present amongst the heterogeneous native vegetation of this part of the State.



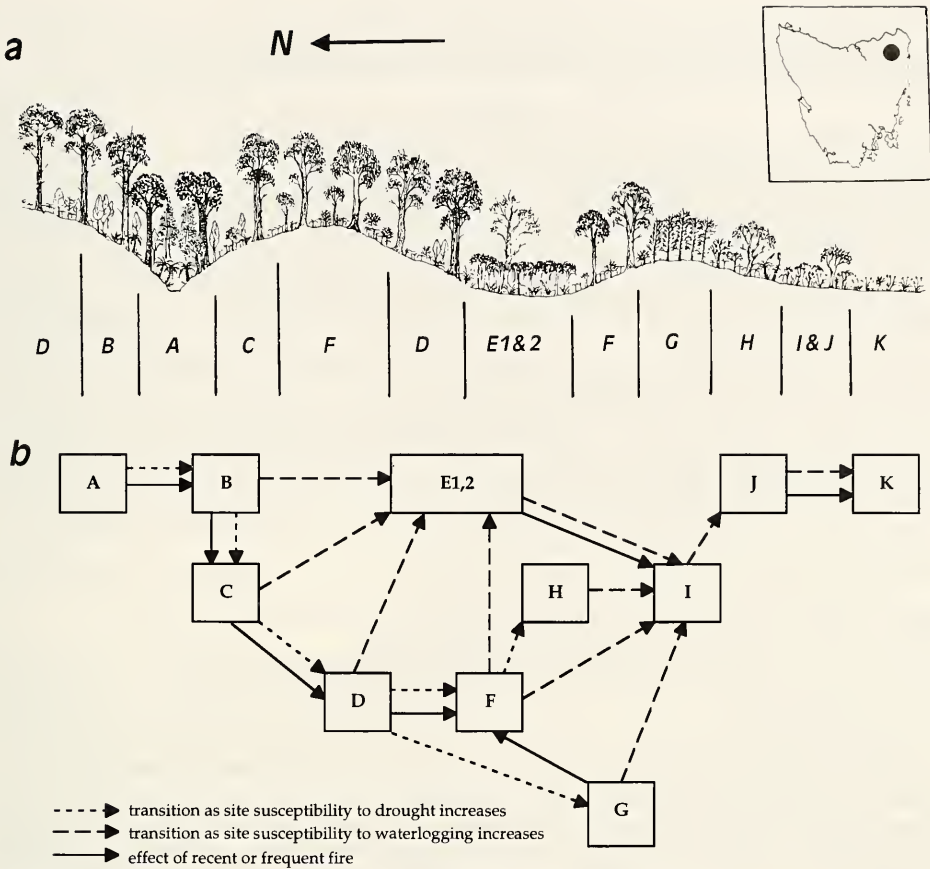


Fig. 3. Relationships between vegetation and environment in the Old Chum Dam area.

- (a) Representation of changes in the vegetation across the landscape (approx. vertical exaggeration 3:1), indicating structural differences between communities. Inset shows location of the study area.
- (b) Response of plant communities to changes in three major environmental variables.

Plant groups: **A** *Acacia melanoxylon* gully forest; **B** *Eucalyptus obliqua* tall wet sclerophyll woodland; **C** *E. obliqua* tall wet sclerophyll forest; **D** *E. obliqua* – *E. amygdalina* damp sclerophyll forest; **E1** Scrubby *E. obliqua* – *E. amygdalina* dry sclerophyll woodland; **E2** Scrubby *E. amygdalina* dry sclerophyll woodland; **F** Heathy *E. amygdalina* – *E. obliqua* dry sclerophyll forest; **G** *Allocasuarina littoralis* closed forest; **H** Heathy *E. amygdalina* dry sclerophyll woodland; **I** Sedgely *E. amygdalina* woodland/scrub; **J** Sedgely *E. ovata* low woodland/scrub; **K** *Gymnoschoenus sphaerocephalus* moorland.

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## APPENDIX 1.

### Descriptions of plant communities, Old Chum Dam area

#### GROUP A: *Acacia melanoxylon* gully forest

*Acacia melanoxylon* gully forest is associated with gullies and creeklines, often forming a narrow corridor along these, but in some instances occupying well drained stream flats. Sites are relatively humid and protected from fire by topography and the mesomorphic nature of the vegetation. The position on the catenary sequence explains the relatively high fine particle content of the soils, and consequently their greater water holding capacity and fertility compared with soils on adjacent slopes, which support drier and more flammable forest types. Surface rock cover is low or absent.

The community is characterised by sparse *Eucalyptus obliqua* emergents, exceeding 30m, and a dense secondary tree layer (20–30m) dominated by *A. melanoxylon*. *Atherosperma moschatum* is present on more humid sites. *Dicksonia antarctica*, *Olearia argophylla*, *Pomaderris apetala*, *Coprosma quadridens* and *Bursaria spinosa* form a dense medium to tall shrub layer. The liane *Parsonia brownii* connects the forest floor to the canopy. The ground layer is dominated by pteridophytes, particularly *Blechnum nudum*. *Blechnum watsii*, *Polystichum proliferum*, *Culcita dubia*, *Pteridium esculentum* and the sword sedge *Lepidosperma elatius* are also present on most sites, the latter two fern species increasing in abundance as the community grades into wet sclerophyll forests or woodlands. Epiphytic ferns (*Tmesipteris billardieri*, *Polyphlebium venosum*, *Hymenophyllum* spp., *Rumohra adiantiformis*, *Ctenopteris heterophylla*) are widespread, with abundance and diversity being greatest on sites most approaching rainforest (i.e. with *A. moschatum* present). The low light levels reaching the forest floor preclude the development of herbaceous species, though bryophytes are conspicuous on logs and on the ground.

The group can be allocated to the *A. melanoxylon* gully forest community identified by Pannell (1992), and also has affinities with *E. obliqua* — *Acacia dealbata* — *Olearia argophylla* (OB 0110) wet sclerophyll forest (Kirkpatrick *et al.* 1988).



GROUP B: *Eucalyptus obliqua* tall wet sclerophyll woodland

*Eucalyptus obliqua* tall woodland with a wet sclerophyll understorey occurs adjacent to creeks and gullies, and is closely related to *Acacia melanoxylon* gully forest. The microclimate appears to be slightly less humid, hence the paucity of *Atherosperma moschatum* and the absence of a rich epiphytic flora. The sites also tend to have more impeded drainage, resulting in higher soil moisture contents than Group A or Group C sites. As site dryness increases the community grades into *E. obliqua* tall wet sclerophyll forest (Group C), and as drainage becomes more impeded *E. obliqua* tall wet sclerophyll woodland grades into Group E1 vegetation.

The community occurs mainly as woodland, the upper stratum exceeding 30m. *Eucalyptus obliqua* dominates, with *E. viminalis* present as a minor species on some sites. These species also occur in the medium to tall shrub layer, which also includes *Pomaderris apetala* (better drained sites) and *Melaleuca squarrosa* and *Acacia verticillata* (sites where drainage is more impeded). Trunked ferns are prominent: *Dicksonia antarctica* and *Todea barbara* were present on the five sites samples, and *Cyathea australis* on two sites. The ground layer is very dense, compared with that of Group A sites, and dominated by ferns. All of *Blechnum nudum*, *Blechnum wattsii*, *Pteridium esculentum* and *Culcita dubia* occur on most sites. Tall graminoids (*Lepidosperma elatius*, *Gahnia grandis*, *Carex appressa*, *Baumea tetragona*) are mainly associated with microhabitats having somewhat impeded drainage. Herbaceous species are sparse and low in diversity, and bryophytes are less common than in the *Acacia melanoxylon* gully forest.

The community has a close affinity with *E. obliqua* — *Melaleuca squarrosa* — *Monotoca glauca* (OB 0111) wet sclerophyll forest (Kirkpatrick *et al.*, 1988).

GROUP C: *Eucalyptus obliqua* tall wet sclerophyll forest

*Eucalyptus obliqua* tall open forest with a wet sclerophyll understorey occurs on south facing middle to lower slopes. Soils are well drained. The community grades into *Acacia melanoxylon* gully forest or *E. obliqua* tall wet sclerophyll woodland as sites become more humid, but the boundary between the communities tends to be sharp, reflecting more frequent or recent fire in the *E. obliqua* forest.

The community forms a forest, the upper stratum exceeding 30m, dominated by *E. obliqua*, with *E. viminalis* a common subdominant or minor species. The small tree and tall shrub strata are very sparse, with eucalypt regeneration and *Acacia melanoxylon* the main components. The medium shrub layer (1–5m) is dense, resulting in the community having a distinctly layered appearance. The main species are *Pomaderris apetala*, *Monotoca glauca*, *Acacia verticillata*, *Zieria arborescens* and *Coprosma quadrifida*. Scleromorphic shrubs, notably *Pultenaea juniperina* and *Lomatia tinctoria*, are also present. A dense to very dense lower stratum is dominated by ferns (*Culcita dubia* and *Pteridium esculentum*) which often exceed one metre in height. Graminoids (*Lepidosperma elatius*, *Dianella tasmanica*), grasses (*Deyeuxia quadrisetata*) and forbs (*Viola hederacea*, *Acianthus exsertus*) are sporadic, but the shading of the forest floor by the fern fronds is responsible for herbaceous species, in particular, being sparse and depauperate.

On more humid sites the community is similar to *E. obliqua* — *Acacia dealbata* — *Olearia argophylla* (OB 011) wet sclerophyll forest, and on drier sites the community has strong affinities with *E. obliqua* — *Olearia lirata* — *Pultenaea juniperina* (OB 010) wet sclerophyll forest (Kirkpatrick *et al.*, 1988).

GROUP D: *Eucalyptus obliqua* — *Eucalyptus amygdalina* damp sclerophyll forest

*Eucalyptus obliqua* — *E. amygdalina* open forest is a transition community between *E. obliqua* wet sclerophyll forest and *E. amygdalina* dry sclerophyll forest. The community is widespread in the study area, mainly occupying slopes with south to east aspects, and therefore not subject to severe insolation or summer drought. Soil moisture levels are

intermediate between those recorded on wet sclerophyll and dry sclerophyll sites. Soils are well drained, with some sites having a sparse surface rock cover.

The community is dominated by *E. obliqua* and/or *E. amygdalina*. The dominance reflects the site dryness, and the two species are co-dominant on intermediate sites within the community's range. *Eucalyptus viminalis* occurs commonly as a minor species. The canopy is relatively dense and between 20 and 30m in height, with some trees overtopping 30m. The small tree layer is comprised of eucalypt regeneration. The medium to tall shrub layer is very sparse, and mainly comprises *Acacia terminalis*, *Acacia verticillata*, *Olearia lirata* and eucalypt regeneration. Vegetation below one metre is moderately dense, with the relative abundance of scleromorphous shrubs (*Pultenaea juniperina*, *Lomatia tinctoria*, *Epacris impressa*, *Leptospermum scoparium*) and bracken (*Pteridium esculentum*) probably reflecting fire history. *Culcita dubia* is present on moister sites, while graminoids (*Lepidosperma* spp. *Dianella tasmanica*, *Gahnia grandis*) are present but sparse on many sites. Forbs and grasses contribute little biomass but are more abundant and diverse than in wetter forest communities. Species occurring on most sites include *Lagenifera stipitata*, *Goodenia lanata* and *Chiloglottis reflexa*. Bryophytes are virtually absent.

The community has strong affinities with shrubby siliceous *E. obliqua* sclerophyll forest (Duncan and Brown, 1985) and *E. obliqua* — *Olearia lirata* — *Pultenaea juniperina* (OB 010) wet sclerophyll forest (Kirkpatrick *et al.* 1988). The name damp sclerophyll reflects the position of the community between these two vegetation types.

#### GROUP E1: Scrubby *Eucalyptus obliqua* — *Eucalyptus amygdalina* woodland

Dense myrtaceous scrub with emergent *E. obliqua* and *E. amygdalina* is strongly associated with basins and soaks with impeded drainage. The community grades into wet sclerophyll woodland (Group B) or damp sclerophyll forest (Group D) as drainage improves. Soil moisture content is relatively high, reflecting the location of the sites on the catenary sequence. The sites sampled have not been burnt for at least 20 years, resulting in the development of the dense shrub understorey.

*Eucalyptus obliqua* and *E. amygdalina* are co-dominant in most stands, with *E. ovata* being present on some sites. Trees are considerably sparser, lower in height and poorer in form than those in surrounding forests. A dense to very dense medium to tall shrub layer is dominated by *Melaleuca squarrosa*, which achieves greatest densities on the most poorly drained sites. *Leptospermum scoparium* and *Acacia verticillata* are also prominent in this layer. *Acacia terminalis* (towards the drier fringes of the community) and *Leptospermum lanigerum* are occasional. The ground layer is also dense and is dominated by sedges (*Gahnia grandis*, *Lepidosperma elatius*) and ferns (*Blechnum nudum*, *Blechnum wattsii*, *Gleichenia microphylla*, *Pteridium esculentum*). Grasses and forbs are extremely sparse under the dense canopy, though bryophytes are more common than in other communities dominated by *E. obliqua*.

The community has affinities with *E. obliqua* — *Melaleuca squarrosa* — *Monotoca glauca* (OB 0111) wet sclerophyll forest (Kirkpatrick *et al.*, 1988).

#### GROUP E2: Scrubby *Eucalyptus amygdalina* woodland

Dense myrtaceous scrub with emergent *E. amygdalina* has strong floristic and structural affinities with Group E1. Both communities occur on poorly drained basins, and are characterised by high soil moisture contents. The main difference between the communities is the absence of *E. obliqua*, and the lower height of the dense shrub stratum (2 – 5m, compared with 5 – 10m), in the Group E2 sites. This suggests that Group E2 sites are marginally less fertile or more insolated than Group E1 sites. The community grades into damp sclerophyll forest (Group D) or dry sclerophyll forest (Group F) as drainage improves.

The emergent *E. amygdalina* are of spreading, woodland form, and are mainly less

than 15 m in height. A dense medium (2 – 5m) shrub layer is dominated by *Melaleuca squarrosa*, with *Leptospermum scoparium* also present on the margins. The ground layer is also dense, and is dominated by ferns (*Pteridium esculentum* on the margins, *Blechnum* spp. on moister sites, and *Gleichenia* spp. forming tangles) and graminoids (*Gahnia grandis*, *Baumea tetragona*, *Tetraria capillaris*). *Selaginella uliginosa* grows on bare sites on the forest floor.

The community has affinities with sedgey *E. amygdalina* woodland (Duncan and Brown, 1985).

GROUP F: Heathy *Eucalyptus amygdalina* — *Eucalyptus obliqua* dry sclerophyll forest.

*Eucalyptus amygdalina* — *E. obliqua* open forest with a heathy understorey is widespread in the study area, mainly occupying well-drained middle and upper slopes subject to moderate drought stress. The community is structurally and floristically similar to Group D and grades into this community as slopes become more humid. The community grades into heathy *E. amygdalina* forest (Group H) as sites become more insolated or drought-susceptible, and into scrubby *E. obliqua* — *E. amygdalina* woodland (Group E1) or sedgey *E. amygdalina* woodland (Group 1) as drainage becomes more impeded.

The community is mainly dominated by *E. amygdalina*, with *E. obliqua* occurring as a co-dominant on moister sites and as a subdominant elsewhere. Eucalypt regeneration contributes to the 10 – 20m secondary tree layer cover. The medium shrub layer is very sparse, mainly comprising eucalypt regeneration and occasional *Acacia terminalis*. The low shrub/ground layer is moderately dense and is mainly dominated by bracken (*Pteridium esculentum*). *Leptospermum scoparium* is the main lower shrub species; *Lomatia tinctoria*, *Epacris impressa* and *Amperea xiphoclada* are also present but uncommon on most sites. The sparseness of understorey shrubs, and the relative density of bracken, suggests that this community is burnt frequently. Herbaceous species include *Goodenia lanata* (present on all sites) and *Gonocarpus tetragynus*, *Eriochilus cucullatus*, *Chiloglottis reflexa* and *Xanthosia dissecta* (occasional). Bryophytes are extremely rare.

The community has strong affinities with a facies of heathy *E. amygdalina* forest, described by Duncan and Brown (1985).

GROUP G: *Allocasuarina littoralis* closed forest.

*Allocasuarina littoralis* closed forest occurs locally on broad ridges or flats. Soils have a high sand content and appear to be well drained, though on some sites the community grades into woodland or scrub occupying sites with impeded drainage. *Allocasuarina littoralis* closed forest is more typically surrounded by heathy *E. amygdalina* — *E. obliqua* dry sclerophyll forest (Group F). The two communities have many species in common, but are structurally very different, reflecting the absence of fire in *Allocasuarina littoralis* closed forest for some decades.

The community is characterised by a very dense stratum (12 – 18m) of *Allocasuarina littoralis*, overtopped by occasional eucalypts. The density of *A. littoralis*, coupled with the presence of a deep litter layer, inhibits the development of an understorey, except under gaps in the canopy and at the margins of the community. The main species recorded were *Banksia marginata*, *Leptospermum scoparium*, *Lomatia tinctoria* (shrubs), *Pteridium esculentum* (bracken), *Lepidosperma laterale*, *Diplarrena moraea*, *Gahnia grandis* (graminoids), *Ehrharta distichophylla* (grass) and *Goodenia lanata* (forb). The club moss *Lycopodium deuterodensum* is occasional.

The community is not described in the literature but has some affinities with heathy *E. amygdalina* forest (Duncan and Brown, 1985).

GROUP H: Heathy *Eucalyptus amygdalina* dry sclerophyll woodland

*Eucalyptus amygdalina* woodland with a diverse, heathy understorey occurs locally in



the general area, and more extensively to the north on the naturally vegetated remnants of the hinterland plains. The two sites sampled were about 5 km north of the main study area. Both were relatively flat, and characterized by very sandy soils, with low moisture and organic carbon contents. However, variations in microtopography may be responsible for the presence of many species typical of sites with impeded drainage. Some sites supporting recently fired examples of this community were much less diverse than the sites sampled.

The community is dominated by *E. amygdalina*, of spreading form and less than 15m in height. Canopy cover varies from open woodland to forest, but is mainly less than 20 per cent. *Eucalyptus amygdalina* is also conspicuous in the tall shrub/small tree layer, as are *Allocasuarina littoralis* and *Banksia marginata*. The 1 – 5m shrub layer also contains these species, but is dominated by *Leptospermum scoparium*, *Kunzea ambigua* and *Xanthorrhoea australis*. The low shrub layer and ground layers are particularly diverse, and include *Boronia pilosa*, *Epacris impressa*, *Aotus ericoides*, *Allocasuarina monilifera* and *Hibbertia procumbens* (shrubs and under-shrubs); *Gahnia grandis*, *Gahnia radula*, *Lepidosperma concavum*, *Leptocarpus tenax*, *Patersonia fragilis* and *Hypolaena fastigiata* (graminoids); and *Pteridium esculentum*, *Selaginella uliginosa* and *Lindsaea linearis* (pteridophytes).

The community is included in heathy *E. amygdalina* forest (Duncan and Brown, 1985). The community is also analogous to Group 0110, described by Kirkpatrick and Wells (1987) for the Great Northern Plain.

#### GROUP I: Sedgely *Eucalyptus amygdalina* woodland/scrub.

Sedgely *E. amygdalina* woodland/scrub is a transition community between heathy *E. amygdalina* woodland (Group H) and sedgely *E. ovata* low woodland/scrub (Group J). The community occurs on the margins of drainage basins and flats, on sites with impeded drainage, which are also insolated.

Stunted *E. amygdalina* forms a distinct stratum between 5 and 12m in height. *Eucalyptus ovata* is occasional. A moderately dense 1 – 2m shrub layer is dominated by *Melaleuca squarrosa*, *Melaleuca squamea* and *Leptospermum scoparium*. Other shrubs typical of poorly drained sites (*Boronia pilosa*, *Boronia parviflora*, *Epacris lanuginosa*) are also present. The ground layer is moderately dense and is dominated by graminoids (*Gymnoschoenus sphaerocephalus*, *Empodisma minus*, *Gahnia grandis*, *Leptocarpus tenax*, *Lepidosperma filiforme*, *Patersonia fragilis*, *Restio complanatus*). Other species (e.g. *Pteridium esculentum*, *Ehrharta distichophylla*, *Stylidium graminifolium*, *Gonocarpus tetragynus*) are found on better drained sites. *Lindsaea linearis* and *Selaginella uliginosa* are common ground cover species.

The community has affinities with sedgely *E. amygdalina* woodland (Duncan and Brown, 1985) and is similar to Group 0110, described by Kirkpatrick and Wells (1987) for the Great Northern Plain.

#### GROUP J: Sedgely *Eucalyptus ovata* low woodland/scrub.

Sedgely *E. ovata* low woodland/scrub occurs on poorly drained flats, at the margins of buttongrass moorland (Group K), or as a later successional stage of that community. Soils sampled had a relatively high moisture content.

Sparse emergent, *E. ovata* overtop a dense 1 – 5m shrub layer, dominated by *Melaleuca squarrosa*, *Melaleuca squamea*, *Leptospermum scoparium* and *Leptospermum lanigerum*. *Epacris lanuginosa* and *Sprengelia incarnata* occurred on all sites sampled. The ground layer is also dense and is dominated by graminoids (*Gymnoschoenus sphaerocephalus*, *Gahnia grandis*, *Leptocarpus tenax*, *Patersonia fragilis*, *Restio complanatus*). *Pteridium esculentum* (bracken) occurs on better drained sites. *Gleichenia dicarpa* forms locally dense thickets. *Selaginella uliginosa* is the most conspicuous of the prostrate herbaceous species.

The community has affinities with sedgely *E. ovata* woodland (Duncan and Brown, 1985), and can also be ascribed to the Common Wet Eastern Heathy facies of Eastern

Moorland (Jarman *et al.*, 1988). It can also be related to group 0100, described by Kirkpatrick and Wells (1987) for the Great Northern Plain.

GROUP K: *Gymnoschoenus sphaerocephalus* moorland.

Moorland dominated by buttongrass (*Gymnoschoenus sphaerocephalus*) occurs on broad flats (or plains), generally towards the centre of these landforms. Sites are poorly drained, and soils sampled had a high organic content, a relatively high moisture content, and a relatively low sand content. One of the moorlands has been burnt 2 to 3 years previously, but Kirkpatrick and Wells (1987) and Jarman *et al.* (1988) suggest that the distribution of moorlands of this type has an edaphic basis. The presence of several shrubs also common to sedgely *E. ovata* low woodland/scrub (including *E. ovata*) suggests that the moorland could succeed to woodland/scrub in the absence of fire or other disturbance.

*Gymnoschoenus sphaerocephalus* contributes most of the biomass to the community. Other graminoids are also common; they include *Leptocarpus tenax*, *Xyris operculata*, *Baumea* spp., *Patersonia fragilis* and *Empodisma minus*. *Gleichenia dicarpa* forms tangled patches. Shrubs to one metre occur throughout the community and include *Melaleuca squarrosa*, *Melaleuca squamea*, *Leptospermum lanigerum*, *Leptospermum scoparium*, *Epacris lanuginosa* and *Comesperma retusum*. The myrtaceous shrubs, and occasional individuals of *E. ovata*, are sporadic emergents above the sedgeland, to a height of 5m. Bare ground between clumps of sedges supports small graminoids and herbs, including *Selaginella uliginosa*, *Gonocarpus micranthus*, *Drosera pygmaea* and *Centrolepis fasciculata*.

The community is consistent with the structure and composition of the Lowland Eastern Sedgely facies of Eastern Moorland (Jarman *et al.*, 1988). It would probably be included in Group 0100 from the Great Northern Plain (Kirkpatrick and Wells, 1987), though that group is fairly diverse, containing heath and scrub as well as sedgeland associations.